

Figure 6-20. Initial LightSquared Deployment (2391 of 40000+ Towers)
Aircraft at 500'

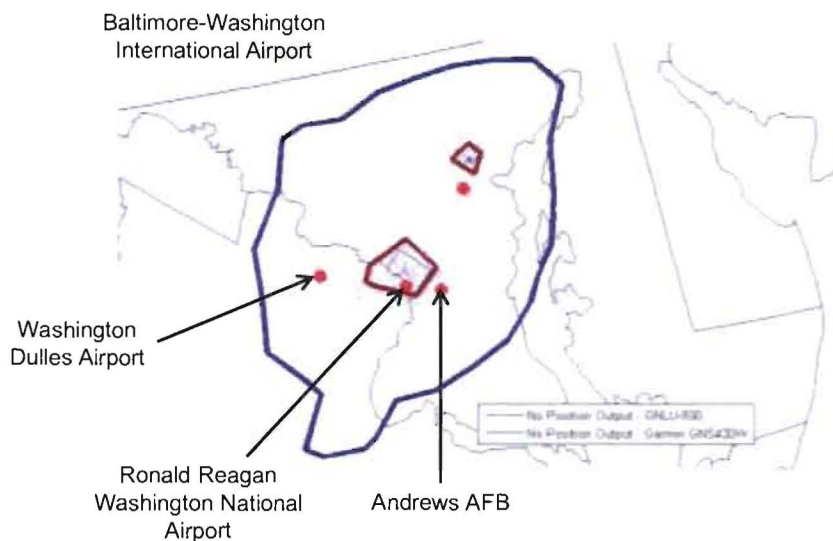


Figure 6-21. Initial LightSquared Deployment (2391 of 40000+ Towers)
Aircraft at 500' (Zoom View above Baltimore-Washington)

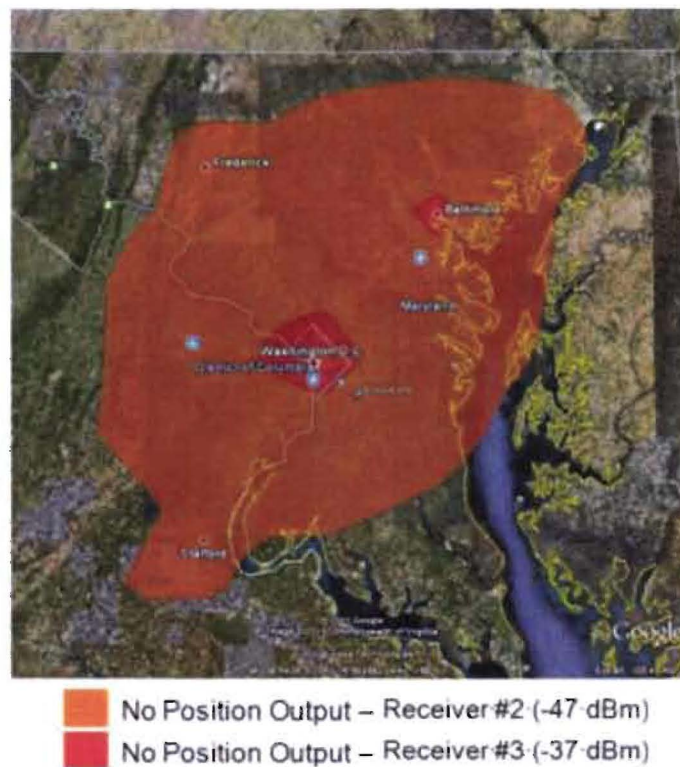


Figure 6-22. Initial LightSquared Deployment Aircraft at 500'

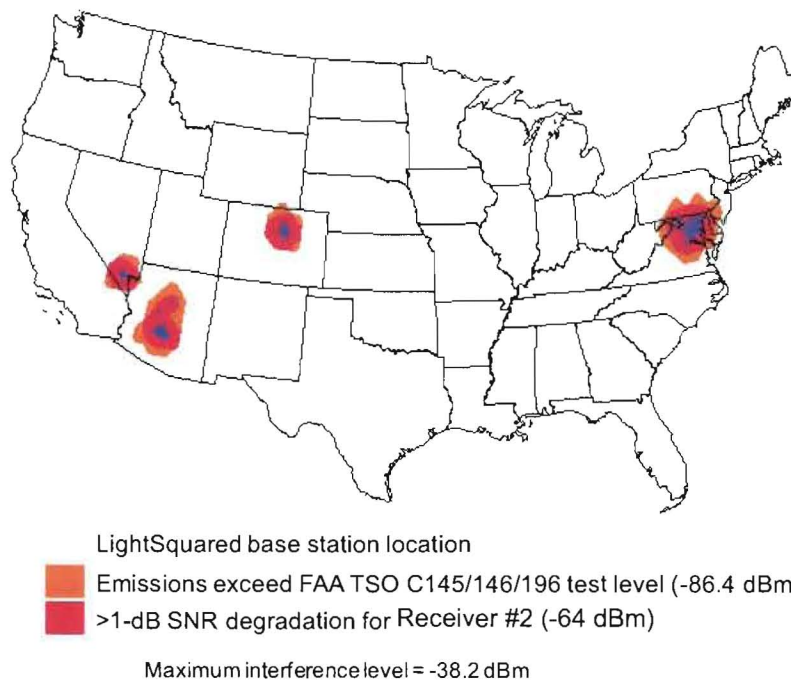


Figure 6-23. Initial LightSquared Deployment Aircraft at 1,000'

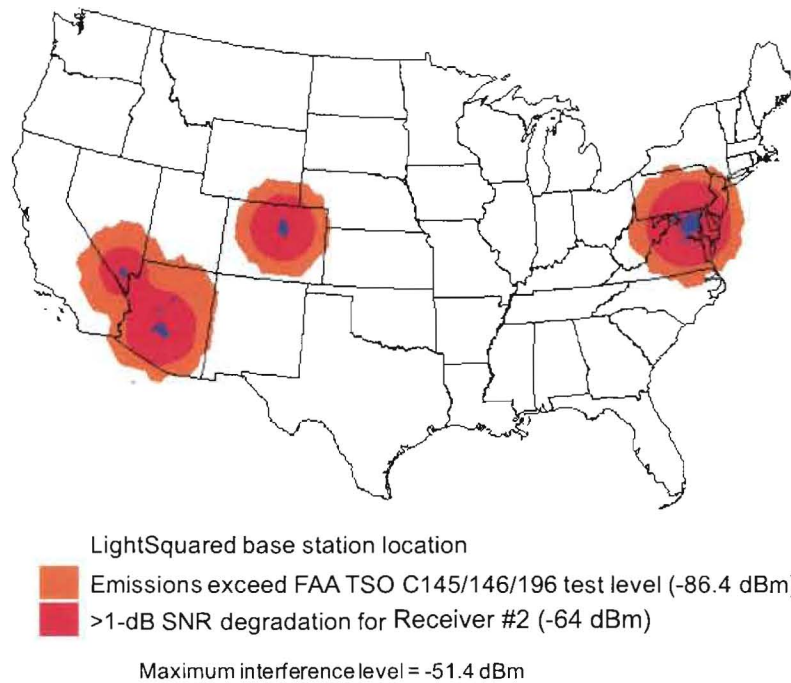


Figure 6-24. Initial LightSquared Deployment Aircraft at 10,000'

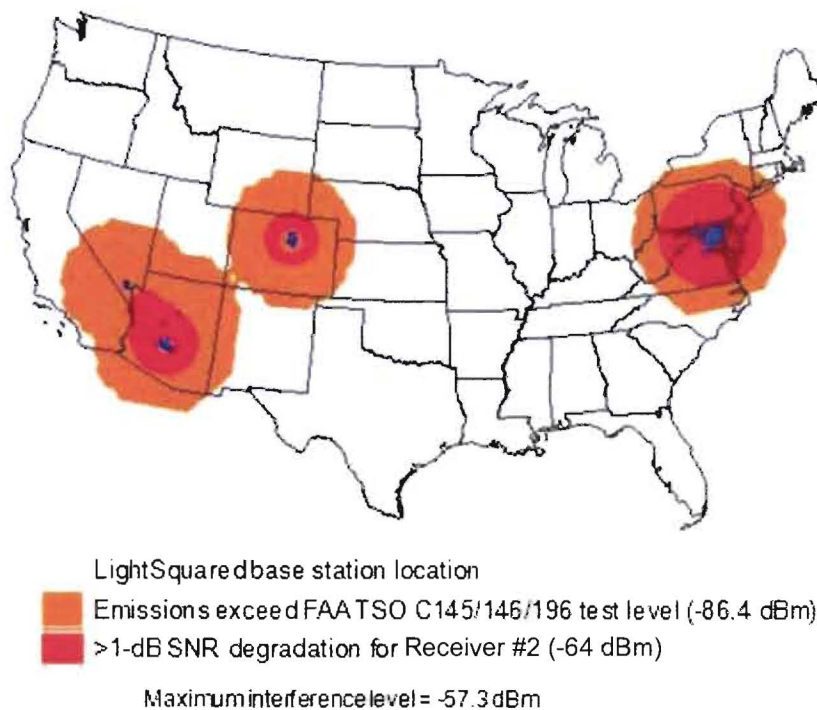


Figure 6-25. Initial LightSquared Deployment Aircraft at 20,000'

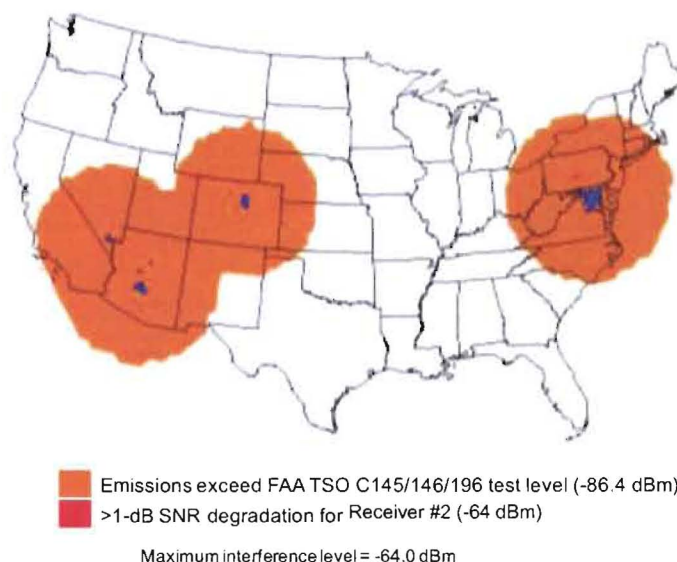


Figure 6-26. Initial LightSquared Deployment Aircraft at 40,000'

Intermodulation Product Simulation

Overview

This report provides an assessment of intermodulation products that may arise in some GPS receivers due to high-powered LightSquared ancillary terrestrial component (ATC) base station emissions driving low noise amplifiers (LNAs) within the receiver into saturation.

LNA Model

Consider the simple LNA system model shown in Figure 6-27. The LNA takes an input voltage, $x(t)$, which is typically the filtered output of a passive antenna element, and provides an output voltage, $y(t)$, with a nominal power gain of G . This note focuses on a typical airborne active antenna LNA that provides a nominal power gain of 34.5 dB².

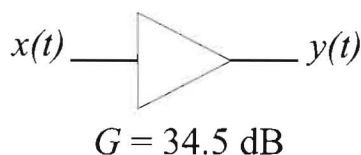


Figure 6-27. Low Noise Amplifier System Model

² Per RTCA DO-301, the overall active antenna amplifier subassembly must provide a minimum gain of 26.5 dB and a nominal gain of 29.5 dB. The nominal gain of 34.5 dB, used here for the LNA subcomponent, presumes 5 dB of losses for, e.g., pre-/post-selection filters and burnout protection circuitry.

For an ideal LNA, the input-output voltage characteristics may be described as:

$$y = a_1 x \quad (1)$$

where $a_1 = \sqrt{G}$ with G being the nominal power gain .

As is well-known, actual LNAs are only well-modeled by (1) for small input voltages. For larger input voltages, the output voltage saturates. A truncated Taylor series expansion is often used (see, e.g., [1]) as a more accurate model:

$$y = \sum_{i=1}^N a_i x^i \quad (2)$$

For example, Figure 6-28 shows the voltage input-output characteristics of an LNA modeled using equation (2) with $N = 5$ and the following coefficients:

$$\begin{aligned} a_1 &= 53.088 \text{ (unitless)} \\ a_2 &= 0 \\ a_3 &= -997490 / R \text{ (volts}^{-2}\text{)} \\ a_4 &= 0 \\ a_5 &= 6.5e9 / R^2 \text{ (volts}^{-4}\text{)} \end{aligned} \quad (3)$$

Where $R = 50 \, \Omega$ is the resistance assumed to relate voltage to power. The a_1 coefficient was selected as $a_1 = \sqrt{G}$ to provide a nominal gain of 34.5 dB. The a_2 and a_4 coefficients were selected as zero to provide an odd-symmetric input-output voltage characteristic.

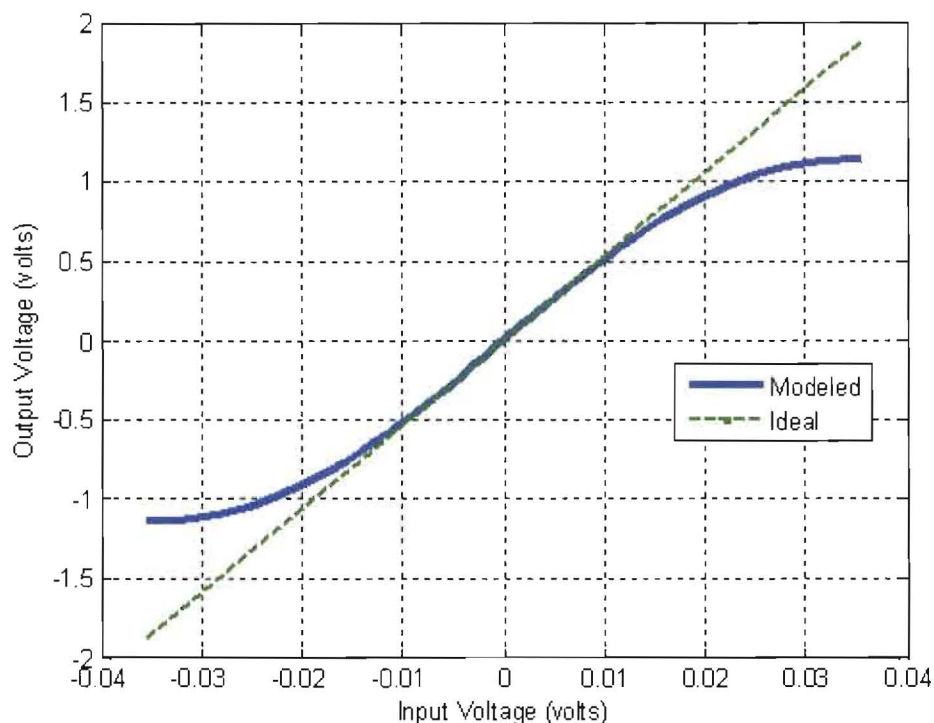


Figure 6-28. Input-Output Voltage Characteristic for Modeled Airborne Active Antenna LNA

a_3 was selected to achieve a representative *1-dB compression point* and *third-order intercept point*. The 1-dB compression point, P_1 , is either the input (*input 1-dB compression point*) or output (*output 1-dB compression point*) power level at which the LNA provides 1-dB less gain than an ideal LNA with the same nominal gain value. Figure 6-29 shows the input-output power characteristics of the modeled LNA. Airborne antenna active subassemblies are required to have an input 1-dB compression point above -25 dBm within the passband. These subassemblies are defined to include protection circuitry and a preselector filter between the passive antenna output port and LNA input port. The modeled LNA is consistent with this requirement, providing an input 1-dB compression point of -22.2 dBm (see Figure 6-29), which would provide an input 1-dB compression point above -20 dBm for the overall active subassembly presuming combined insertion losses of greater than 2.2 dB for the preselector filter and protection circuit.

The concept of the third-order intercept point is explained, e.g., in [1]. A typical LNA has a third-order intercept point, P_3 , which is 10 – 15 dB above its 1-dB compression points (provided that both are consistently referenced to either the input or output). The magnitude of the a_3 coefficient in equation (3) was selected using the formula [4]:

$$P_{3,output} = \frac{2a_1^3}{3|a_3|} \quad (4)$$

and a target $P_{3,input}$ value that was set to 10 dB above a target $P_{1,input}$ value of -24.5 dBm. The sign of a_3 was chosen to be negative, since this is required for gain suppression rather than gain